Front Resolving Observational Network with Telemetry: Turbulence Characterization from an AUV

Edward R. Levine
Naval Undersea Warfare Center, Division Newport
Code 8211
Newport, RI 02841-1708
phone: (401) 832-4772 fax: (401) 832-2146
email: levineer@tech.npt.nuwc.navy,mil
Award #: N0001499WX20680
http://www.sp.uconn.edu/~wwwmsd/nopp_pgm/noppprop.html

LONG-TERM GOALS

A Front-Resolving Observational Network with Telemetry (FRONT) is being developed for a region of the coastal ocean. The long term goal is to demonstrate and evaluate an easily deployed, easily serviced, and cost-effective observation system.

OBJECTIVES

The specific objectives of the AUV-based turbulence characterization component of this research are to contribute to the evaluation the overall performance of the observation system in this challenging environment. We will provide the microstructure scale comparison with assimilated data products, as part of results from a series of ship surveys designed to resolve multiple scales of variability.

APPROACH

The FRONT system includes data-assimilative models that will mitigate the impact of sampling error by producing dynamically consistent maps from the data. Furthermore, real-time coordination of the diverse range of physical and biological data will allow forecasting. Data telemetry and instrument control for the bottom-mounted instrument array employs a wireless acoustic communications network with redundant data paths. The demonstration site lies in a region of strongly varying bathymetry on the shelf near Long Island Sound (Fig. 1). Tides and energetic wind- and buoyancy-forced motions combine to produce a complex flow field. Satellite measurements of surface temperature and color show recurrent front-like features at the FRONT site (Ullman and Cornillon, 1999). To evaluate the observation system fidelity, we will compare model results to observational results on multiple scales from microstructure through the mesoscale.

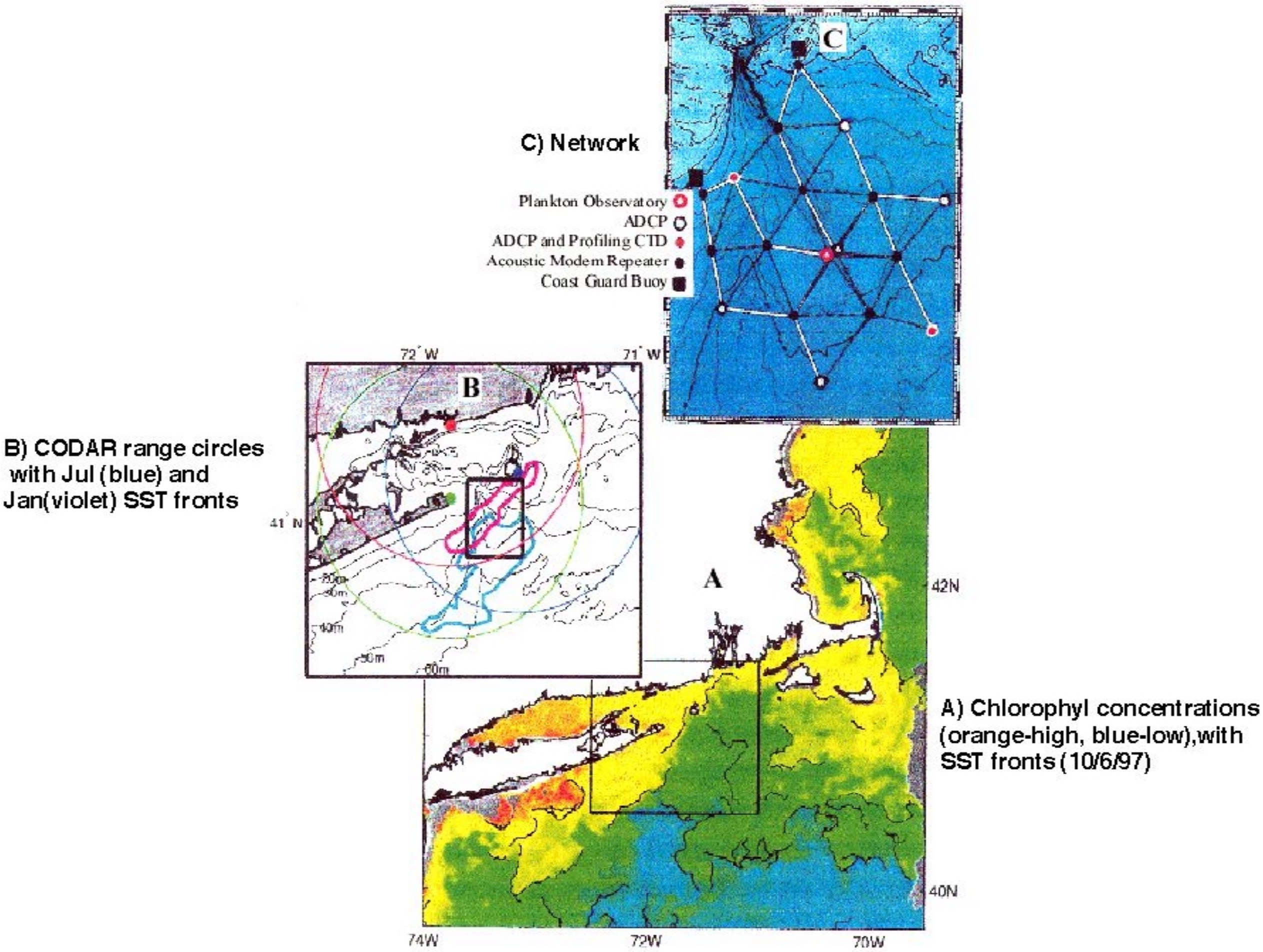

Fig 1. The FRONT observational network

For the turbulence measurements, my approach is to integrate an optimum turbulence sensor suite into a small, logistically simple, AUV. A turbulence sensor package was electrically and mechanically integrated into the REMUS AUV (Levine et al, 1999) (Fig. 2). Sensors include two shear probes, an ultra-fast thermistor, an upward and downward looking ADCP, two CTDs, and an ADV-O. Towards this end, I obtain horizontals profiles of dissipation rate, temperature microstructure, 3-dimensional small scale velocity, larger scale vertical shear of horizontal current, and stratification in the coastal environment. The sensors provided data for estimates of eddy diffusivity profile (Gargett and Moum (1995), eddy viscosity profile (using the truncated TKE equation), bulk and gradient Richardson numbers, and fluxes [using the correlation technique]. In addition, our data will be compared with simultaneous towed data from the Microsoar conductivity probe**.** These data enable us to evaluate subgrid mixing processes in the coastal circulation version of the MITgcm model (Marshal et al, 1997) being adapted for the FRONT region

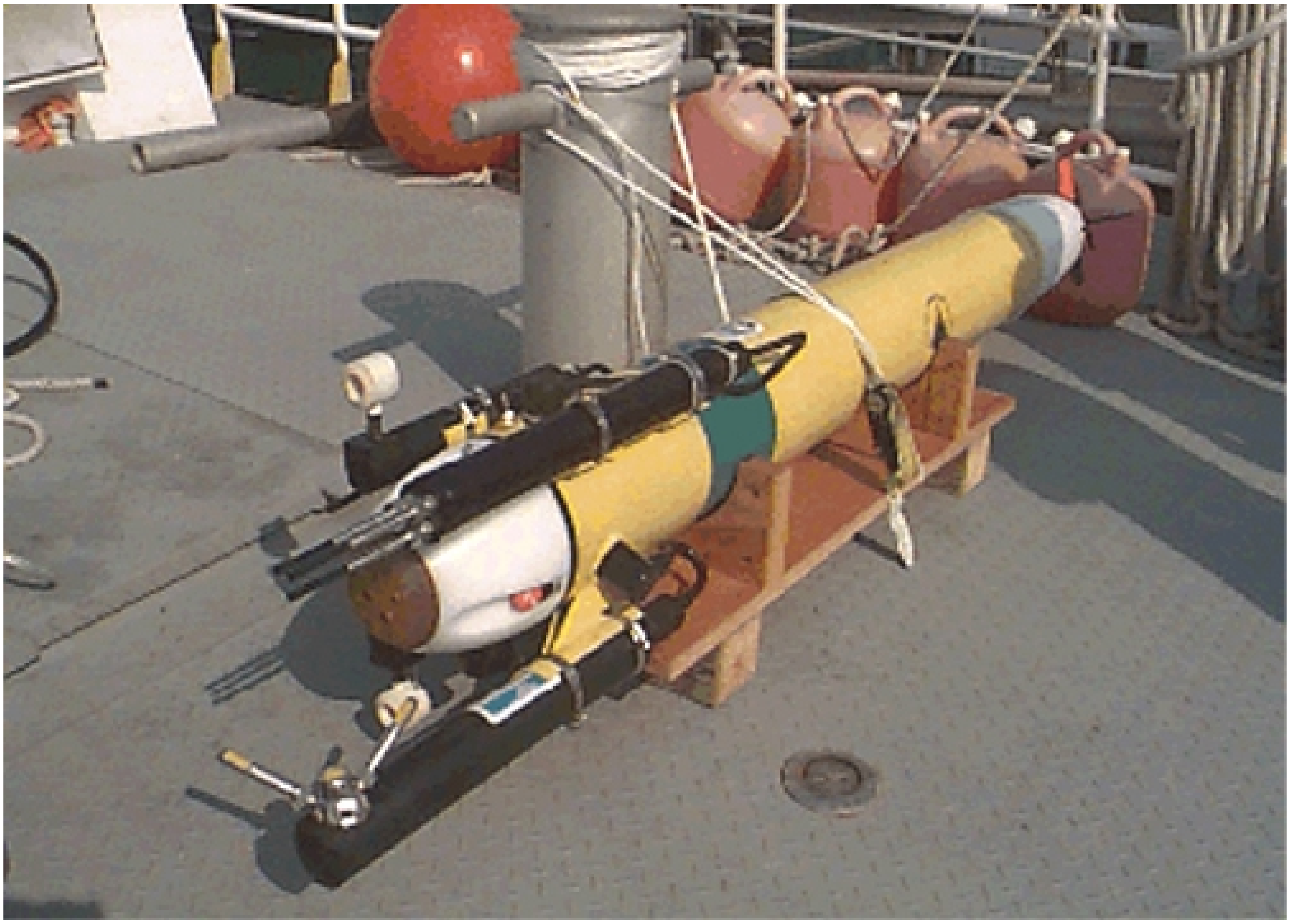

Fig 2. The REMUS AUV instrumented with turbulence sensors

WORK COMPLETED

During FY1999, planning for the FY2000 field program and data/modeling comparison was conducted with other FRONT P.I.'s. Analysis of data from previous experiments, is aiding in refining analysis techniques for the new challenges of the FRONT research. Past experience with other research vessels and test deployments from the RV UConn will aid in improving and extending our capabilities to the more challenging environment of the FRONT experiment during multiple seasons. Initial field testing of the turbulence measuring system will be conducted during the FRONT1 period during fall 1999.

RESULTS

In previous experiments, results indicate that the modified REMUS AUV was a viable platform for turbulence data acquisition in the coastal ocean (Levine et al, 1999). For example, the shear probe data are processed to remove noise associated with vehicle vibrations. This process is done using data from accelerometers located in the probe pressure case directly behind the probe mounts, utilizing the techniques of Levine and Lueck (1999). Consistently, comparisons of computed autospectra agree well with the Nasmyth "universal spectrum" (Oakey, 1982) out to wavenumbers close to the physical size of the sensing tip of the shear probes.

IMPACT/APPLICATION

The AUV-based turbulence measurements provide a unique horizontal profiling view of the variability of the mixing environment that cannot be obtained by more conventionally sampling measurements, and this approach can be further exploited in yo-yoed horizontal sections. These techniques will be invaluable in frontal process studies utilizing the coastal version of the MITgcm model.

TRANSITIONS

Our AUV sensor technologies, hardware and software, are being considered for inclusion as tactical oceanography payloads for the Manta UUV Initiative.

RELATED PROJECTS

My AUV-based turbulence measurement system is also being utilized in NOPP/ONR studies with the Rutgers University led LEO-15 and Harvard University led LOOPS projects.

REFERENCES

A. E. Gargett and J. N. Moum. 1995: Mixing effects in tidal fronts: results from direct and indirect measurements of density flux. J. Phys. Ocean. , 25, 2583-2608.

Levine, E. R., R. G. Lueck, 1999: Turbulence measurements with an autonomous underwater vehicle. Journal of Atmospheric and Oceanic Technology, Special Issue on Ocean Turbulence Measurement, 16, 11, part 1, 1533-1544.

Levine, E. R., R. G. Lueck, R. R. Shell, and P. Licis, 1999: Coastal turbulence estimates and physical process studies utilizing a small AUV, Proceedings, Eleventh International Symposium on Unmanned Untethered Vehicle Technology (UUST99), Durham, NH. 94-102.

Marshal, J. , C. Hill, L. Perelman, and A. Adcroft, 1997: Hydrostatic, quasi-hydrostatic, and non-hydrostatic ocean modeling. J. Geophys. Res, 102(C3), 5733-5752.

N. S. Oakey. 1982: Determination of the rate of dissipation of turbulent energy from simultaneous temperature and velocity shear measurements. J. Phys. Ocean., 12, 256-271.

Ullman, D. S. and P. C. Cornillon, 1999: Surface temperature fronts off the east coast of North America from AVHRR imagery. submitted to J. Geophys. Res..

PUBLICATIONS

Bogden, P. S., and FRONT Partners, 2000: Front-Resolving Observational Network with Telemetry (FRONT). Abstract invited for AGU/ASLO Ocean Sciences Meeting, Special Session on Coastal Ocean Dynamics and Prediction, San Antonio, January 2000.

Levine, E. R., R. G. Lueck, 1999: Turbulence measurements with an autonomous underwater vehicle. Journal of Atmospheric and Oceanic Technology, Special Issue on Ocean Turbulence Measurement, 16, 11, part 1, 1533-1544.

Levine, E. R., R. G. Lueck, R. R. Shell, and P. Licis, 1999: Coastal turbulence estimates and physical process studies utilizing a small AUV, Proceedings, Eleventh International Symposium on Unmanned Untethered Vehicle Technology (UUST99), Durham, NH. 94-102.